Designs of new NMR technique and device material toward a solid-state quantum computer

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The goal of our research is developing a new NMR technique and synthesizing a device material to realize a solid-state quantum computer.

We have at the present three technical problems to achieve that.

Firstly we need to know what kind of nuclear spin interaction would be the best for quantum computation, and also what kind of material should be synthesized to make it possible. There are four major interactions available among nuclear spins; nuclear dipole (in any materials), Ruderman-Kittel (in metals), Suhl-Nakamura (in magnets), *J*-coupling (in covalent bonding). Among them only the nuclear dipole interaction can be known by calculation. We have developed software called "dipole simulator" working on Windows PC's, which simulates the strength and angular dependence of dipole interaction in any materials with given crystal structure. We expect that the simulator can be appreciated as a guide principle to design a best material for the computer device.

Second problem is that we need an innovative NMR initialization technique to obtain a quantum mechanically pure state in nuclear spin system for keeping a quantum-entangled state. We expect an OPNMR (optically pumped NMR) in semiconductors as a promising solution to make it three orders of magnitude better.

OPNMR can also be another promising solution for the third problem, which needs an innovative improvement of sensitivity of NMR signal itself. This is because we will need a multi-channel NMR to operate large qubits given on a nano size device, and therefore the NMR signal will be extremely weak. Applying a polarization transfer technique from the optically pumped semiconductor to the overlayers deposited on it can be a solution for the problem.

Developing an OPNMR system is now in progress. We acknowledge Dr. S. Machida of the Quantum Entanglement Project, ICORP, JST for his technical help on optical system.